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The distribution and fluvial redistribution of soil organic carbon in semiarid rangelands

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Compared to other terrestrial biomes, the carbon dynamics of drylands have attracted relatively little attention, perhaps due to their characteristically low primary productivity, low soil organic carbon (OC) contents and slow OC turnover rates. However, covering approximately 40% of the land surface, drylands represent a significant component of the global terrestrial carbon sink. Our study examines the distribution and fluvial redistribution of particulate-associated OC over a dynamic grass to shrub ecotone in semiarid central New Mexico, USA.

Surface soil (0-0.05 m) samples from beneath different vegetation covers across the ecotone were collected and physically fractionated by density (>1 g ml) and particle size (one phi intervals from <0.0625 to >4 mm, with no deliberate dispersion of aggregates). There were significant (P<0.05) differences in OC concentration between different particle-size fractions, with peaks in the silt-clay (<0.0625 mm) fraction, and, unexpectedly, in the three coarse-medium sand (2-1, 1-0.5, and 0.5-0.25 mm) fractions. As soil erosion by runoff is particle size-selective, this suggests estimating erosional carbon fluxes as a function of total sediment flux may be overly simplistic. Given that many soil erosion models already explicitly consider the transport of several particle size classes, we believe that the results presented here justify the particle-size variant parameterisation of OC concentration, which we are currently working to implement. Importantly, both of the coarsest (>4 and 4-2 mm) fractions had OC concentrations comparable to the <2 mm average, attributed to the aggradation of finer primary particles which suggests that, in dryland soils at least, the current practice of ignoring the >2 mm fraction may underestimate the magnitude of the soil OC sink.

In addition to topsoil characterisation, we monitored natural erosion events from four 300 m2 runoff plots over four monsoon seasons, capturing all eroded sediment which was fractionated as detailed above. Substantial variability in bulk sediment OC enrichment between rainstorm events and between monsoon seasons demonstrates the need for multi-year studies to understand these ecohydrological systems. Intriguingly, average OC enrichment increases substantially as shrub domination increases. Historically, many studies have attributed whole-sediment OC enrichment to changes in particle-size distribution, on the basis of strong correlations between particle-size distributions and whole-sediment OC concentration enrichment. However, our results demonstrate substantial OC enrichment within all particle-size fractions, particularly in fine sand fractions, suggesting that this perceptual model is incomplete.

We argue that advancing our understanding of OC redistribution by erosion requires detailed mechanistic examination of transport processes, in conjunction with numerical simulations to address the challenges of upscaling such process understanding.